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Municipal Affairs
and Housing

**TECHNICAL SERVICES DIVISION
RESEARCH & DEVELOPMENT SECTION**

26V

CANADIAN SINGLE STACK PLUMBING
DEMONSTRATION PROJECT

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and

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SUMMARY

This report covers the installation and testing carried out on a Canadian single stack drainage, waste and vent system installed in an Ontario Housing Corporation Senior Citizen Residence at Kirkland Lake, Ontario. The basis of design is set forth along with the pass/fail criterion, test load selection and test procedure. Acceptance tests and a series of research tests were carried out and the results reported and discussed.

It is concluded that the Canadian Single Stack system is a safe and viable alternative DWV system to current systems and can be constructed with a considerable reduction in cost.

Recommendations are made concerning further research and the inclusion of the system in appropriate plumbing codes.

Abbreviations and Symbols

WC	Water Closet
BT	Bath Tub
LAV	Lavatory
KS	Kitchen Sink
BG	Bathroom Group (WC, BT, & Lav)
D	Double (BG or KS)
RG	Residential Group (WC, BT, LAV & KS)
X	Fixture discharged
-	No Reading Taken



1.0

INTRODUCTION

For some time the Ministry of Municipal Affairs and Housing has been interested in constructing a low rise residential building that incorporates the Canadian Single Stack Drain Waste and Vent (DWV) System that was being developed at the National Research Council of Canada in the seventies. Research had shown that the system was safe from a plumbing health point of view and could significantly reduce the cost of the plumbing system. One of the objections to including the single stack system in Canadian plumbing codes was that it had not been tried out in an actual building. To overcome this, the Research and Development Section of the Ministry of Municipal Affairs and Housing proposed a demonstration of the system in an O.H.C. building in Kirkland Lake was accepted by the Board of Directors of Ontario Housing Corporation. In addition, because the information gained would be of particular interest to the Canada Mortgage and Housing Corporation, they were invited to participate as a partner in research activity.

1.1

OBJECTIVES AND SCOPE

The principal objectives of this project were to gain practical experience in the use of the Canadian Single Stack System and to determine its cost advantage over currently acceptable DWV systems. While the principal DWV system used would be the Canadian Single Stack system, it was anticipated that the venting of some fixtures located in special rooms on the ground floor, would require special considerations. Testing of the system to prove it is capable of handling the design loads and investigating its performance under much heavier loads is also included. Finally, it is hoped that the information gained will make a significant contribution towards getting the single stack DWV system accepted by the various Provincial and Canadian Plumbing Codes.

1.2

DESIGN BASIS

The Canadian Single Stack System is a vented DWV system although some people consider it an un-vented system. It is a system where the piping serves both as drainage piping and as vent piping. Consequently the capacity of a stack in the Canadian Single Stack System is much less than a soil-or-waste pipe in the dry vented system. When the system was being developed at the National Research Council it was found that certain piping arrangements prohibited by current plumbing codes actually reduced the amount of trap seal loss in the new system. These arrangements have been included in the new system. The Canadian Single Stack System complies with the Canadian Plumbing Code except as follows:

- (1) Stack fittings used shall be of the following type:
 - (a) Single or Double Sanitary Tees
 - (b) Single or Double Sanitary Tees with tapped side inlet(s)
 - (c) Single or Double Combination Y and 1/8th Bends
 - (d) Single or Double Combination Y and 1/8th Bends with tapped sides inlet(s)
 - (e) Single or Double Y's
- (2) Trap arm and trap arm brand fittings shall be of the following type:
 - (a) Elbows
 - (b) Single Sanitary Tees
 - (c) Single and Double Y's
 - (d) Single and Double Combination Y and 1/8th Bends
- (3) Double Y and Double Y and 1/8th Bend fittings may be used in the horizontal position.
- (4) Traps shall have a minimum trap seal depth of 2".

- (5) A fixture, such as a floor drain or Janitor's mop receptor need not be protected where its trap arm is at least 3" in size.
- (6) Except for WC's and as provided in (5), the fall between the trap weir and the stack fitting shall not exceed the trap size.
- (7) Where a minor fixture is located on the lowest floor and its trap arm has a vertical section, the vertical section shall:
 - (a) be extended as a continuous vent that is connected to a wet vented stack or
 - (b) be one size larger than the trap it serves.
- (8) Horizontal trap arms of back to back fixtures may be combined provided that the size of the combined section is at least 1½".
- (9) Stacks shall:
 - (a) be extended as a stack vent,
 - (b) not change size from its base to outside air, and
 - (c) not be offset.
- (10) The maximum load drained to a stack shall be limited according to the size of the stack as follows:
 - (a) 4" size: 8 Residential Groups
 - (b) 3" size: limit not fully established but none necessary for this project, and
 - (c) 2" size: 5 KS, one per floor, with a 2" relief vent at mid height.

1.3

COST REDUCTION

The Senior Citizen Residence is 5 storeys in height and contains 49 units. There are 12 units on each of 4 floors plus a caretaker's unit on the lowest or ground floor, which also contains a laundry room, common room and washrooms. The plumbing layout for a typical floor is shown in

Fig. 1. The General Contractor was responsible for completing the design and for the construction of the building to Ontario Government's specifications, except for the plumbing for which design drawings were supplied.

The Contractor was required to submit his quotation on the basis of the supplied plumbing drawings and to quote the difference in cost if the DWV system was installed in accordance with the Ontario plumbing code. The Contractor quoted an extra of \$10,000.00 which corresponds to a saving of \$204.00 per unit by using the Canadian Single Stack DWV System.

1.4

DETAILS OF CONSTRUCTION

The contract specifications and the Canadian Single Stack DWV system provided a certain amount of flexibility to the Contractor. Particular Details of Construction that were incorporated into the building are as follows:

- (1) Piping 3" and larger is hub cast iron.
- (2) Piping 2" and smaller is copper.
- (3) As the more economical double fittings with side inlets are not readily available in Ontario, the Sub-Contractor used double fittings, usually Sanitary Tees.
- (4) Back to back fixtures were generally connected to the copper branch by a Y fitting.
- (5) Characteristics of the principal fixtures were determined experimentally and are as follows:
 - (a) Water Closet: American Standard Plebe, close coupled Reverse Trap with insulated tank. Bowl capacity, 3.3 L. Flushing quantity 18.8 L, flushing time 15 S, Flush and refill time 59 S, Trap seal depth 70 mm., Water surface 248 mm x 270 mm.
 - (b) Bath Tub: American Standard Salem (5') with PO plug. Capacity 90.0 L when filled to a depth of 160 mm. Discharge time 3 min. 4 S. Trap 1½" brass with an estimated trap seal depth of 57 mm.

- (c) Lavatory: American Standard Ovation with PO plug. Capacity 6.0 L when filled to a depth of 78 mm. Discharge time 11 S. Trap removable 1½" chrome plated brass with a trap seal depth of 78 mm.
- (d) Kitchen Sink: American Standard Prestige with crumb cup. Capacity 18.0 L when filled to a depth of 107 mm. Discharge time 30 S with crumb cup in and 22 S with crumb cup out. Trap removable brass 1½" with a trap seal depth of 90 mm.
- (6) At the time the DWV system was being designed, it was not known what effect an overload of 2 kitchen sinks would have on a 2" stack. Research had shown that it could handle 1 kitchen sink discharging which is actually the theoretical test load for a system of 15 fixtures. Anticipating that the corridors would have hung ceilings, it was felt that the decision to provide an interconnecting relief vent could be postponed until some on-site testing had been carried out. Later, when it was found that the Contractor would be installing drywall ceilings, the decision was made to install an interconnecting relief vent on the 3rd floor ceiling for stacks 7, 8 and 9 and stacks 15 and 16.
- (7) During the first inspection visit, it was discovered that two stacks had been incorrectly located. The Contractor corrected the misalignment by installing offsets rather than by the very costly method of breaking out the lower floor and relaying the branch connection. The Canadian single stack requirements however, specifically prohibit the use of offsets because their effect on the system is not fully known. Considering all the facts, a decision was made to install a 1½" relief vent between the two minor fixtures above and below the offsets.

- (8) The stacks range in size from 2" to 4" with varying hydraulic loads. In the normal system these loads are expressed in terms of fixture units. In wet vented single stack systems they are generally specified in terms of fixtures or groups of fixtures. Details and schematic piping diagrams of the stacks on which the acceptance and research tests were carried out are shown in Fig. 2.

1.5 PASS/FAIL CRITERION

The criterion used by the United States National Bureau of Standards, the British Research Establishment and the National Research Council of Canada are very similar and give similar results.

The Pass/Fail Criteria adapted for this project is as follows:

The maximum loss of seal shall not exceed 50% of the trap seal depth and the minimum trap seal retention shall be 25 mm. when the system is subjected to three consecutive applications of the design test load without refilling of the idle traps between discharges of the test load.

1.6 TEST LOADS

The various research agencies mentioned above also use similar methods to determine the number of fixtures in the test load and to select them. The number of fixtures to be discharged is determined by the Poisson's probability function.

$$P_r = \frac{n!}{r! (n-r)!} p^r (1-p)^{n-r} \quad \text{where}$$

n = the cumulative sum of the probabilities
 r that any 0 to r fixtures and no other
 fixtures in the system will be found
 discharging

P = the individual probability that a fixture
 will be found discharging

r = the number of fixtures found discharging

n = the number of fixtures in the system

$:$ = the factorial symbol (e.g. 3: - 3 x 2 x 1)

The individual probability P is determined by the equation:

$$P = \frac{t}{T} \text{ where}$$

t = the length of time of discharge (seconds)

T = the time between discharges (fixture usage) (seconds).

The criterion used by the other research agencies is that the peak design load will not occur more than 1% of the time during the 1 hour of peak fixture usage per day. The peak period of use for each fixture tends to occur at different times of the day, but for simplification and as a safety factor they are assumed to coincide. Fixture characteristics also vary both by type and by manufacturer's models. This could cause a problem since it is desirable to be able to use a single individual probability to represent all fixtures in a mixed system. Fortunately, it turns out that the individual probabilities of the minor fixtures are very similar to that of the major fixture, the water closet, so that a single value can be used with safety. Based on research and experience, the values representing fixture characteristics and the individual probabilities used are given in Table 1.

Corresponding to the design load, the test load, r, is that minimum number of fixtures from 0 to r, that will be found discharging together more than 99% of the time. The probability and test loads were calculated and are shown in Table 2.

Having determined the size of the test load, it is then necessary to select appropriate fixtures. Research has shown that the maximum negative pressure occurs in a stack just below the point of entry of the discharge. It is caused by a combination of the turbulence at the point of entry and the effect of gravity on the waste below that point. It is obvious then that there are two principal factors to be considered, the height of the fixture and the amount of turbulence caused. With this in mind the current research practice is to select the test load fixtures from those located at the top of the stairs using the order of priority as water closets, bathtubs, kitchen sinks and lavatories.

While calculating the various test loads, the thought occurred that it would be interesting to calculate the probable load on the building sewer during the one hour peak period of use per day. This was done and the results tabulated in Table 3. From this table we can see that we are most likely to find only two fixtures discharging together and that the design load is six fixtures discharging together. The average flow from six fixtures would probably be in the order of 3.0 L/S whereas a 4" building sewer has a capacity of 3.4 L/S when flowing half full. The required size of the building sewer is 6" thus this theory supports the common view that the codes require building sewers to be over designed.

1.7

TEST PROCEDURE

Install water level indicators in the W.C. bowls and U-tube manometers on the minor fixtures, excluding bathtubs for practical reasons. Ensure that all traps are full, set the water level scales to zero or record the water levels. Fill the test fixtures to the test depth.

Discharge the lavatory and bathtub by removing the plug and the kitchen sink by removing the crumb cup. Discharge the water closet in the normal manner.

When the test load consists of more than one fixture, time the discharge of the fixtures so that their peak flows coincide at entry to the stack. Record the time delay.

Record the trap seal loss readings.

Without refilling the traps of idle fixtures, repeat the test a second and third time.

1.8

TESTING

A review of the number of different sized stacks and their hydraulic loading indicated that it was only necessary to carry out acceptance tests on two 4" stacks and one 2" stack. The 3" stack that serves four pairs of back-to-back kitchen sinks is very lightly loaded, and in fact complies with the present Canadian Plumbing Code requirements for multi-storey wet venting. The abbreviations and

symbols used in recording the test data are given on page iii. The results of the acceptance tests and the identity and location of the test load are tabulated in Table 4. In each case the acceptance test was repeated with the test load being located on the 5th floor and then on the 4th floor.

Research tests were carried out on the one 4" stack, one 3" stack and a pair of 2" stacks. Tables 6, 7 and 8 show the various series of tests and the observed trap seal losses that occurred.

1.9

DISCUSSION

The results of the acceptance tests, Table 4a, 4b and 4c, show that the system, as installed, meets the pass/fail criterion. Although not clearly shown in these results, the research tests confirm that the worst stack loadings occur when the highest fixtures discharge. It should be noted that the chance that the highest pair of fixtures will be found discharging together is the same as the chance that the lowest fixtures or any other particular pair of fixtures will be found discharging together. As the test load is repeated three times in succession without any of the other fixtures being used, the trap seal loss that can be expected to occur under normal building occupancy will be considerably less than the amounts recorded during the testing.

Research tests No. R1 to R6 clearly showed that a 4" stack can safely handle much heavier loads than the design load. It is interesting to note that in the United Kingdom 4" stacks can handle back-to-back bathroom groups on 10 floors. This emphasizes the safeness of the current Canadian requirements.

Research test No. R6 was carried out to compare the results of using a simple flexible U-tube manometer that is inserted through the waste opening into the trap rather than replacing the lower half of the trap with one modified for attaching the U-tube. The results were the same. This means that any existing system may be tested with the same accuracy as the laboratory method. The laboratory method has one advantage in the case of minor fixtures and that is that the device does not interfere with using the fixture as part of the test load. Its disadvantages are that they take more time to install and the existing system is really not tested.

Research testing of the 3" stack was limited by its height and the small number of fixtures that it served. With the highest two kitchen sinks being discharged together the trap seal loss was minimal, see Table 5c.

The test load of 2 fixtures corresponds to a system capacity of 44 fixtures. The Canadian Plumbing Code, similar to the B.C. Plumbing Code, limits a 3" stack to 8 kitchen sinks. A test load of 4 fixtures corresponds to a system capacity of 128 minor fixtures. The results of test R8, Table 5C show that 3" stacks are currently under designed. The relative size of the trap arm and the stack are such that the waste produces little turbulence on entry, hence there is little chance of developing a significant negative pressure in the stack.

The tests that were carried out on the pair of 2" stacks indicate that in order to be able to handle an overload of two kitchen sinks discharging together, the capacity should be limited to about 5 to 7 floors with one fixture per floor. Providing some form of relief vent every 3 or 4 floors would allow the capacity to be increased. This practice is followed in Great Britain. For these stacks the permitted trap seal loss is 45 mm as the traps have a trap seal depth of 90 mm. Also the discharge of two fixtures is the theoretical test load for a system of forty-four fixtures. The source of the problem is the similarity in the sizes of the trap arm and stack which makes it easy for turbulence to block off the stack. Although the trap seal losses were the highest recorded on any tests, the system still met the pass/fail criterion even though the loads imposed were heavier than the required acceptance test load. The results are given in Tables R9 to R20.

The normal test load was clear cold water. To see if hot soapy water would produce different results, test R14 was run. There was no difference in the results.

The series of test R15 to R18 was run because the loss of seal from the kitchen sink in Suite 203 was double that of any other traps. This is inconsistent with normal experience and theory.

By discharging the top fixture on each stack, the interconnecting relief vent should not come into play since the pneumatic pressure in each stack should be the same. This is confirmed by the losses that occurred on the third and fourth floors. The results should therefore be similar to testing a five storey stack with one kitchen sink on each floor.

Test R15 was repeated as R16 to confirm the first results. test R17 was a repeat, but this time the crumb cups were not fully removed but placed in the open position. This produced a slight reduction in trap seal loss as was expected. When this test was completed the modified lower half of the traps were removed and the Contractor's traps installed.

The following morning test R18 and R19 were carried out, using flexible tube manometers. The trap seal losses were lower still even though the crumb cups were fully removed. This suggests that the use of traps modified for attaching the manometer may give results that are slightly different to the actual traps used even though supplied by the same manufacturer. Comparing the results of test R19 with test R9 and R10 show the effect of the relief vent and the effect that changing the height of the test fixture has on the trap seal losses.

To investigate the effect of discharging two fixtures on different floors, test R19 was run with two fixtures on stack 15 being discharged and R20 with one on each stack being discharged. The trap seal losses that were recorded were much less than in the previous series. Although no fixtures were discharged on stack 15 in test R19, traps on the stack suffered trap seal losses. These were undoubtedly related to the presence of the interconnecting relief vent but the exact cause is not known.

There is also no explanation for the large trap seal losses suffered by the trap in Suite 203. Although it would be reasonable to find an offset in stack 15, at this point due to the change in wall construction, the Contractor is convinced that the stack runs vertical without an offset. Despite this unresolved problem, the test results clearly show that the stacks can safely handle the heaviest loads that might occur during normal building occupancy.

1.10

CONCLUSIONS

The results of the acceptance and research tests carried out on the Senior Citizen Residence clearly show that the Canadian Single Stack DWV system in its present state of development is an acceptable alternative to the DWV Systems currently permitted by the various Provincial and Canadian Plumbing Codes. The project will also provide evidence to support minor changes to the codes to permit piping arrangements that are not prohibited.

The project also clearly indicates the significant cost savings that can be achieved when the Canadian Single Stack system is used.

The use of flexible U-tube manometers provide a simple way to test for trap seal losses in existing buildings.

1.11

RECOMMENDATIONS

The development of the Canadian Single Stack DWV system needs to be continued so that it can be used effectively in one and two storey buildings, low rise buildings and high rise buildings. This will involve research into all stack sizes from 1½" up to 6". It is suggested that this work be organized as follows:

- (1) Research into the capacity of small stacks and 3" stacks serving water closets be carried out in conjunction with the plumbers apprentice training course at some College of Applied Arts and Technology.
- (2) Research into the capacity of stacks for low and high rise buildings be carried out in the form of desk research followed by the erection of some temporary experimental systems in some suitable location.
- (3) Additional demonstration projects be constructed in co-operation with supportive Provincial Authorities.
- (4) Draft code requirements based on (1) and (2) be prepared and submitted to the various Code Committees.

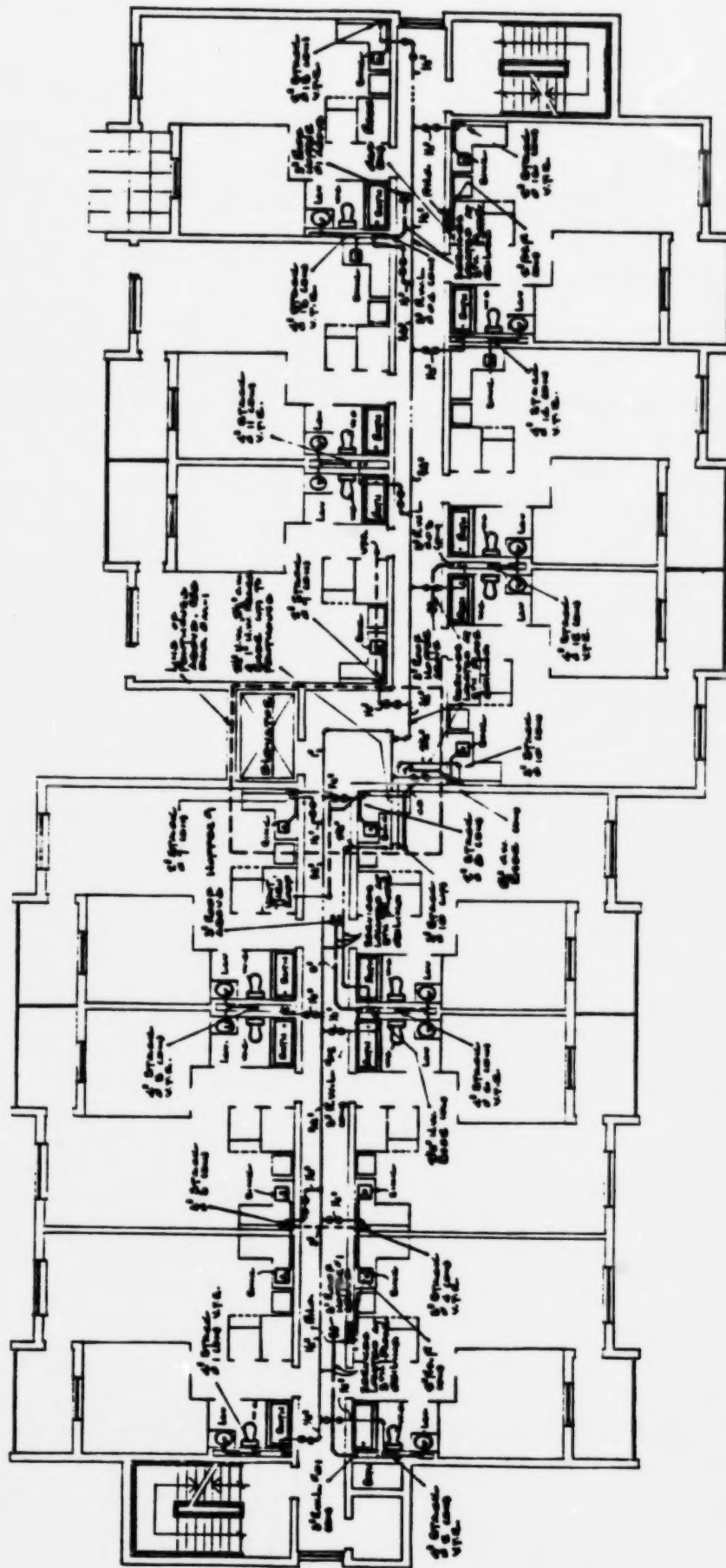


Figure 1. Typical Plumbing Floor Plan

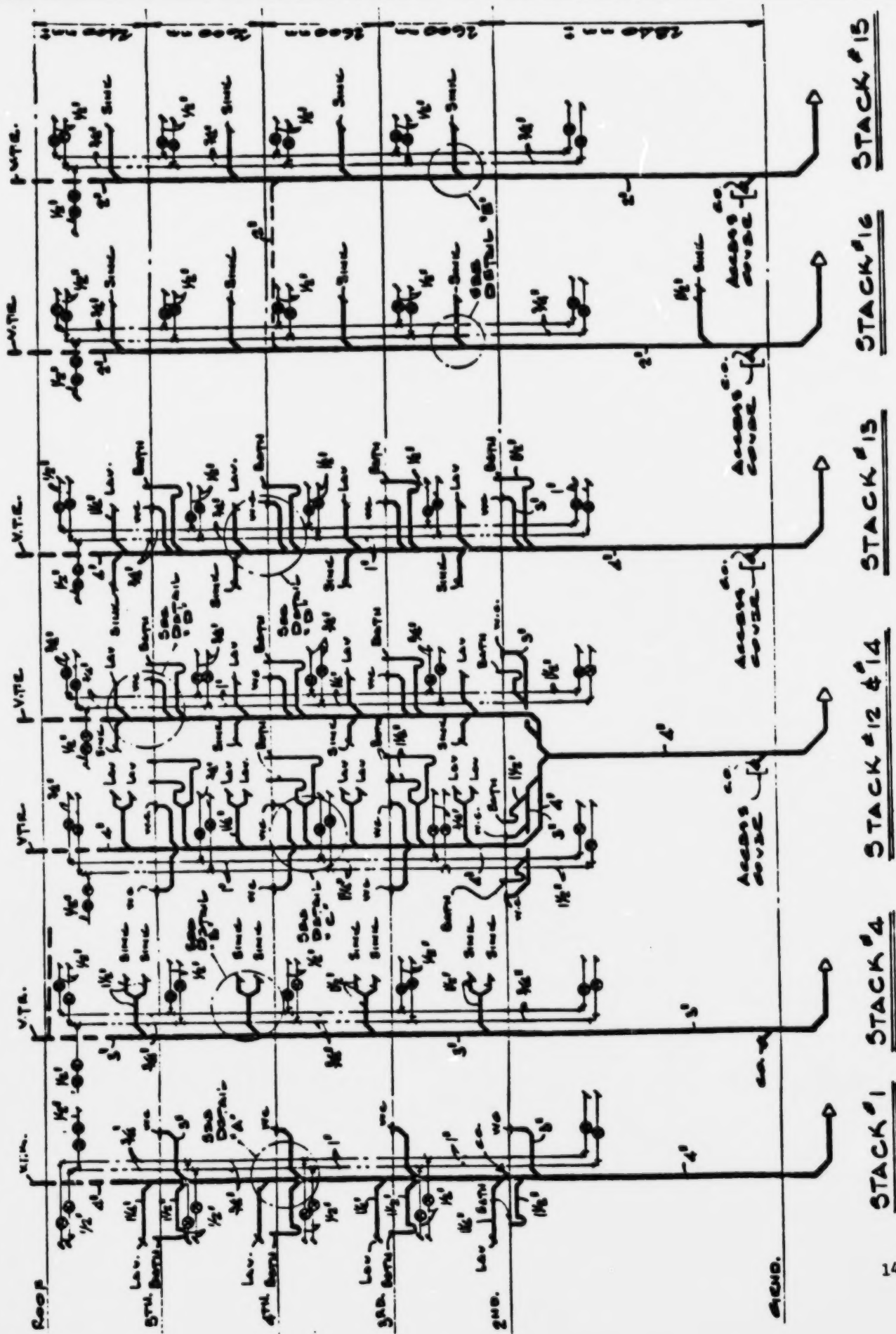
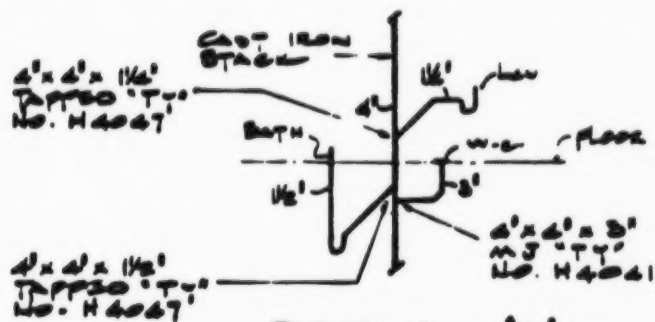
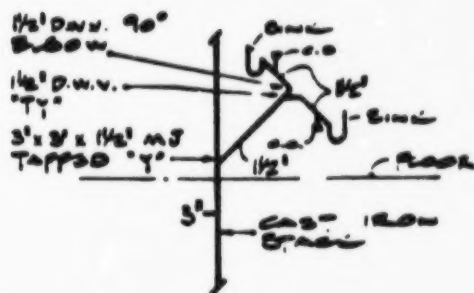


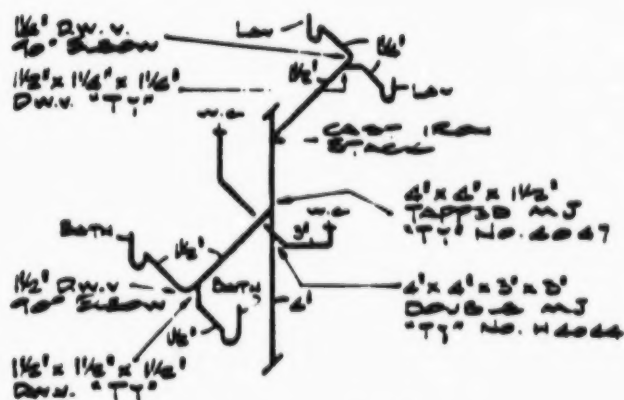
Figure 2. Typical Stack Details



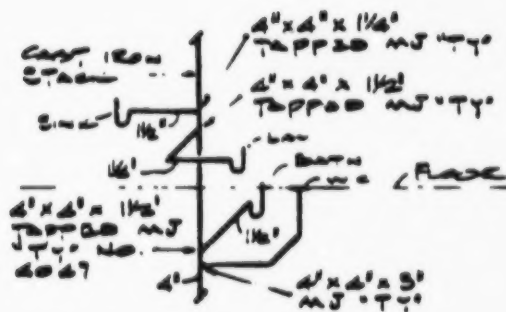
DETAIL 'A'



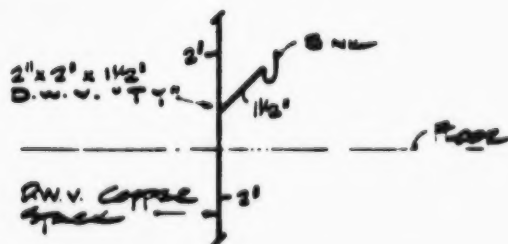
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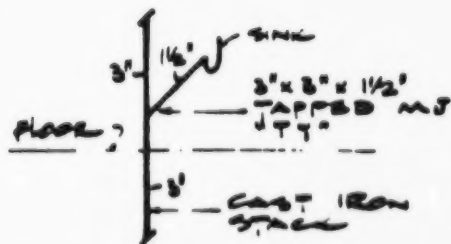
DETAIL 'C'



DETAIL 'D'



DETAIL 'E'



DETAIL 'F'

TABLE 1. Fixture Characteristics and Individual Probabilities.

Fixture	Quantity Discharged litres	Time to Discharge t seconds	Time between Uses T minutes	Individual Probabilities P
WC	17	13	20	0.01
LAV	6.5	13	20	0.01
BT	96	140	240	0.01
KS	22	27	45	0.01

TABLE 2. Typical Stack Probabilities and Test Loads.

Size of Stack inches	No. of Fixtures on Stack(1)	Probability of finding r Fixtures discharging				Number of Test Load Fixtures
		0	1	2(2)		
4	24	0.7857	0.1904	0.0221	0.9982	2
4	16	0.8515	0.1376	0.0104	0.9995	2
4	12	0.8864	0.1074	(0.0060)	0.9938	1
3	8	0.9227	0.0746	(0.0026)	0.9973	1
2	5	0.9510	0.0480	(0.0007)	0.9990	1
2	4	0.9606	0.0388	(0.0006)	0.9994	1

Notes: (1) Some fixtures on the lowest floor are connected to the branch rather than the stack.

(2) The figures in brackets are not included in the sum given in the second last column.

TABLE 3. Building System Probabilities.

r, the no. of fixtures found discharging	Probability of finding r fixtures discharging together	Probability of finding from 0 to r fixtures discharging together
0	0.122	0.122
1	0.258	0.380
2	0.272	0.652
3	0.189	0.841
4	0.098	0.938
5	0.041	0.980
6	0.014	0.994

Notes: (1) There are 209 fixtures in the building.

(2) Column 3 is a summation of the individual probabilities given in Column 2.

TABLE 4a. 4 in. Stack, Test Loads WC and BT

4 in. Stack No. 12		Cumulative Trap Seal Loss, mm.					
Suite	Fixture	Test A1			Test A2		
		A	B	C	A	B	C
506	WC	X	X	X	-	-	-
506	BT	X	X	X	-	-	-
505	WC	0	0	0	0	0	0
505	LAV	0	0	0	0	0	0
406	WC	3	4	4	1	1	1
406	LAV	6	7	8	2	2	2
405	WC	-	-	-	X	X	X
405	BT	-	-	-	X	X	X
306	WC	3	3	3	3	3	3
306	LAV	3	3	3	3	3	3
206	WC	2	2	2	3	3	3
206	LAV	1	1	1	0	0	0

Maximum permitted trap seal loss:

WC - 35 mm
 BT - 28 mm
 LAV - 29 mm

- Notes: (1) Test load 2 fixtures
- (2) WC discharge delayed 1 second
- (3) Tests A1 and A2 are described in paragraph 1.8 on page 8 and 9. The acceptable trap seal loss is 50% of the trap seal depths given in paragraph 1.4 on page 4 and 5.

TABLE 4b. 4 in. Stack, Test Loads WC and KS

4 in. Stack No. 13		Cumulative Trap Seal Loss, mm.					
Suite	Fixtures	Test A3			Test A4		
		A	B	C	A	B	C
502	KS	X	X	X	-	-	-
503	WC	X	X	X	-	-	-
503	LAV	0	1	1	-	-	-
402	KS	0	1	1	X	X	X
403	WC	3	4	4	X	X	X
403	LAV	4	5	6	1	1	1
302	KS	0	0	0	0	0	0
303	WC	0	0	0	2	3	3
303	LAV	4	4	4	2	3	3
202	KS	0	0	0	0	0	0
203	WC	0	0	0	0	0	0
203	LAV	0	0	0	0	0	0

Maximum permitted trap seal loss:

WC - 35 mm
LAV - 37 mm
KS - 45 mm

- Notes: (1) Test load 2 fixtures
(2) WC discharge delayed 1 second

TABLE 4c. 2 in. Stack, Test Load 1 KS

2 in. Stack No. 16		Cumulative Trap Seal Loss, mm.					
Suite	Fixture	Test A5			Test A6		
		A	B	C	A	B	C
503	KS	-	-	-	-	-	-
504	KS	X	X	X	-	-	-
403	KS	0	0	0	0	0	0
404	KS	8	10	11	X	X	X
303	KS	0	0	0	0	0	0
304	KS	3	3	3	4	5	5
203	KS	1	1	1	0	0	1
204	KS	2	3	3	3	3	5
101	KS	4	4	4	2	3	8

Maximum permitted trap seal loss:

KS - 45 mm

- Notes: (1) Test Load on Stack 16 - 1 KS
(2) Readings taken on Stack 15 because of interconnecting relief vent

TABLE 5a. 4 in. Stack, Test Load 2 WC

4 in. Stack No. 12		Cumulative Trap Seal Loss, mm.								
Suite	Fixture	Test R1			Test R2			Test R3		
		A	B	C	A	B	C	A	B	C
506	WC	X	X	X	X	X	X	-	-	-
505	WC	X	X	X	0	0	0	-	-	-
505	LAV	0	0	0	0	1	1	-	-	-
406	WC	12	15	17	2	2	2	X	X	X
406	LAV	14	18	19	2	4	4	2	2	2
405	WC	-	-	-	X	X	X	X	X	X
306	WC	5	7	9	1	2	2	9	11	12
305	LAV	5	6	7	1	2	2	7	9	9
206	WC	2	2	3	5	5	5	2	3	3
205	LAV	1	1	1	5	5	5	0	0	0

Maximum permitted trap seal loss:

WC - 35

LAV - 39

TABLE 5b. 4 in. Stack, Test Loads BG and 2 WC + BT

4 in. Stack No. 12		Cumulative Trap Seal Loss, mm.								
Suite	Fixture	Test R4			Test R5			Test R6		
		A	B	C	A	B	C	A	B	C
506	WC	0	0	0	0	0	0	X	X	X
506	BT	-	-	-	-	-	-	X	X	X
506	LAV	3	3	5	0	0	0	0	0	0
505	WC	X	X	X	-	-	-	X	X	X
505	BT	X	X	X	-	-	-	-	-	-
505	LAV	X	X	X	-	-	-	0	0	0
406	WC	4	6	6	1	1	1	11	13	15
406	WC(1)	-	-	-	-	-	-	11	13	15
406	LAV	8	11	11	1	1	1	15	16	17
406	LAV(1)	-	-	-	-	-	-	15	16	17
405	WC	-	-	-	X	X	X	-	-	-
405	BT	-	-	-	X	X	X	-	-	-
405	LAV	-	-	-	X	X	X	-	-	-
306	WC	2	2	2	2	2	2	3	3	5
306	LAV	3	3	3	1	1	1	5	5	4
206	WC	1	1	1	2	2	2	5	5	5
206	LAV	1	1	1	1	1	1	5	5	5

Maximum permitted trap seal loss:

WC - 35 mm

BT - 28 mm

LAV - 39 mm

Note: (1) Double readings represent two different methods of measuring trap seal loss.

TABLE 5c. 3 in. Stack, Test Loads KS and 4 KS

3 in. Stack No. 3		Cumulative Trap Seal Loss, mm.					
		Test R7			Test R8		
Suite	Fixtures	A	B	C	A	B	C
510	KS	X	X	X	X	X	X
511	KS	X	X	X	X	X	X
410	KS	-	-	-	X	X	X
411	KS	1	2	2	X	X	X
310	KS	-	-	-	-	-	-
311	KS	4	5	6	13	15	17
210	KS	-	-	-	-	-	-
211	KS	5	5	5	8	17	17

Maximum permitted trap seal loss:

KS - 45 mm

TABLE 5d. 2 in. Stack, Test Load 1 KS

2 in. Stack Nos. 15 & 16		Cumulative Trap Seal Loss, mm.								
		Test R9			Test R10			Test R11		
Suite	Fixture	A	B	C	A	B	C	A	B	C
503	KS	X	X	X	-	-	-	-	-	-
504	KS	-	-	-	-	-	-	-	-	-
403	KS	11	14	14	X	X	X	-	-	-
404	KS	-	-	-	-	-	-	-	-	-
303	KS	2	2	2	4	4	4	X	X	X
304	KS	-	-	-	-	-	-	-	-	-
203	KS	5	6	6	7	8	8	8	10	10
204	KS	-	-	-	-	-	-	-	-	-
101	KS	-	-	-	-	-	-	-	-	-

Note: (1) Suite 101 is on Stack No. 16 below Suite 204.

TABLE 5e. 2 in. Stacks, Test Load 1 KS

2 in. Stack Nos. 15 & 16		Cumulative Trap Seal Loss, mm.								
Suite	Fixture	Test R12			Test R13			Test R14		
		A	B	C	A	B	C	A	B	C
503	KS	-	-	-	-	-	-	-	-	-
504	KS	-	-	-	-	-	-	-	-	-
403	KS	-	-	-	-	-	-	-	-	-
404	KS	-	-	-	-	-	-	-	-	-
303	KS	-	-	-	-	-	-	-	-	-
304	KS	X	X	X	X	X	X	-	-	-
203	KS	-	-	-	-	-	-	-	-	-
204	KS	9	12	12	7	12	13	X	X	X
101	KS	3	5	5	3	3	3	3	4	4

Note: (1) Test R14 is the same as Test R13 except that the test load is hot soapy water.

Table 5f. 2 in. Stacks, Test Load 1 KS each Stack

2 in. Stacks Nos. 15 & 16		Cumulative Trap Seal Loss, mm.											
Suite	Fixture	Test R15			Test R16			Test R17			Test R18		
		A	B	C	A	B	C	A	B	C	A	B	C
503	KS	X	X	X	X	X	X	X	X	X	X	X	X
504	KS	X	X	X	X	X	X	X	X	X	X	X	X
403	KS	17	19	19	17	21	23	14	14	14	17	17	17
404	KS	13	14	14	13	16	17	10	10	10	15	17	17
303	KS	17	20	20	14	17	23	5	7	7	13	15	16
304	KS	15	15	15	15	17	20	10	12	12	10	12	13
203	KS	28	30	30	30	31	31	22	27	27	20	23	25
204	KS	14	15	17	13	17	20	13	17	17	14	17	18
101	KS	-	-	-	-	-	-	-	-	-	16	19	20

Notes: (1) Test R17 is the same as R15 and R16 except that the crumb cup was not fully removed.

(2) Test R18 is the same as R15 and R16 except that a flexible manometer was used with the contractor traps installed.

TABLE 5g. 2 in. Stacks, Test Load 2 KS on Different Floors

2 in. Stack Nos. 15 & 16		Cumulative Trap Seal Loss, mm.					
		Test R19			Test R20		
		A	B	C	A	B	C
Suite	Fixtures						
503	KS	-	-	-	-	-	-
504	KS	X	X	X	X	X	X
403	KS	-	-	-	X	X	X
404	KS	X	2	2	X	X	X
303	KS	2	2	2	2	2	2
304	KS	11	12	12	6	8	10
203	KS	5	8	8	8	8	9
204	KS	5	8	10	6	10	11
101	KS	8	10	12	7	10	13

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